

# Cabrillo Port

Interagency LNG Workgroup Meeting  
October 5, 2006  
Seawater Cooling Elimination



Cabrillo Port

# BHP Billiton - World's Largest Diversified resource Co.

## Petroleum



19%

## Aluminium



10%

## Base Metals



23%

## Carbon Steel Materials



30%

## Diamonds & Spec Prod



4%

## Energy Coal



6%

## Stainless Steel Materials



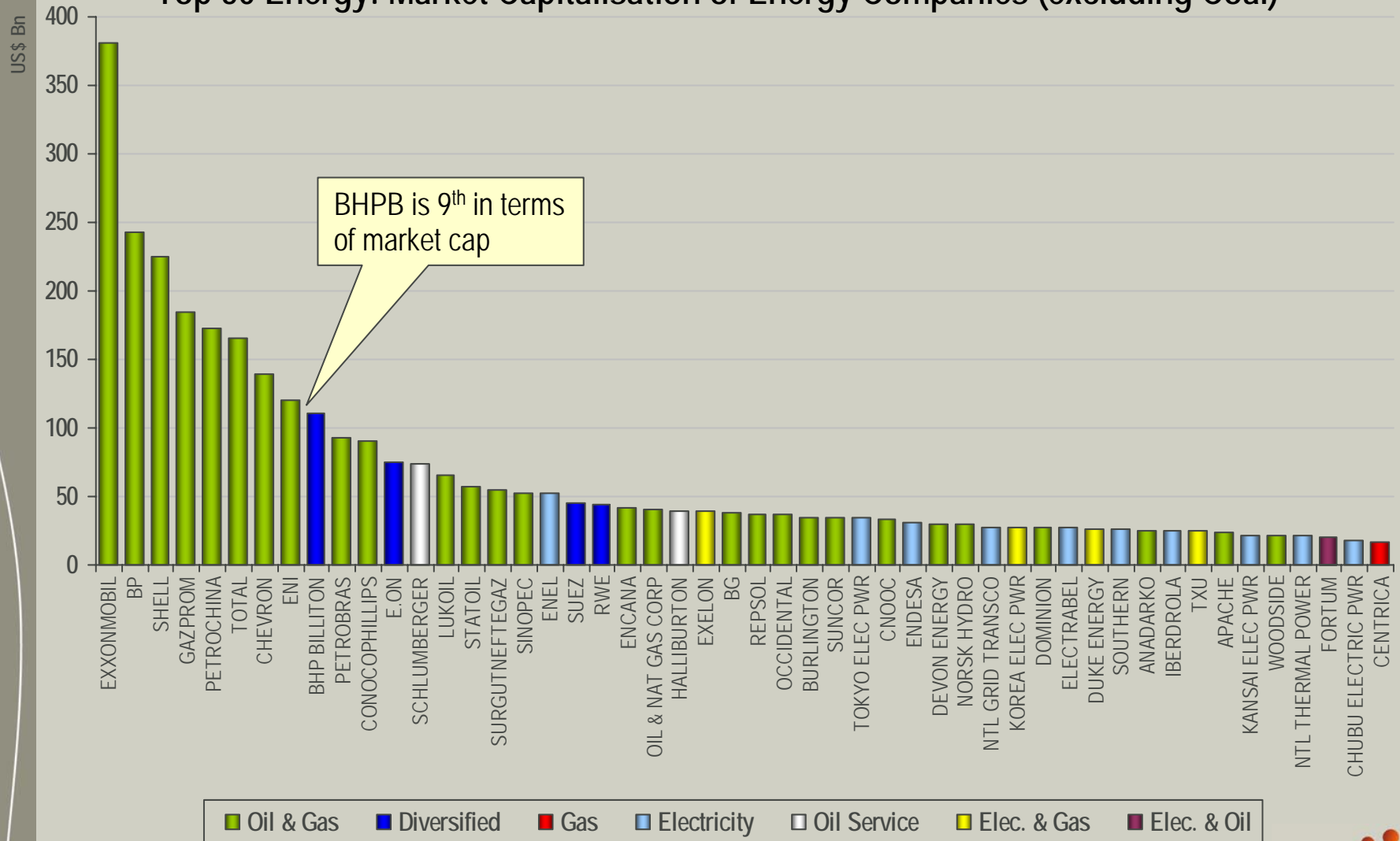
8%



Cabrillo Port

# BHP Billiton Petroleum is the 9<sup>th</sup> Largest Energy Co.

## Top 50 Energy: Market Capitalisation of Energy Companies (excluding Coal)



Source: Bloomberg Data – 24 January 2006

Cabrillo Port

## BHP Billiton – California Connection

- BHP Billiton has a long presence in CA
- One of the State's most recognized landmarks has a BHPB pedigree.
- In 1980's the original wood panels of the Hollywood sign needed replacing
- BHPB furnished the new aluminum-zinc coated steel panels





# Cabrillo Port

## BHPB FPSO Experience



1999 - Buffalo FPSO - Converted 90,000 t dwt tanker

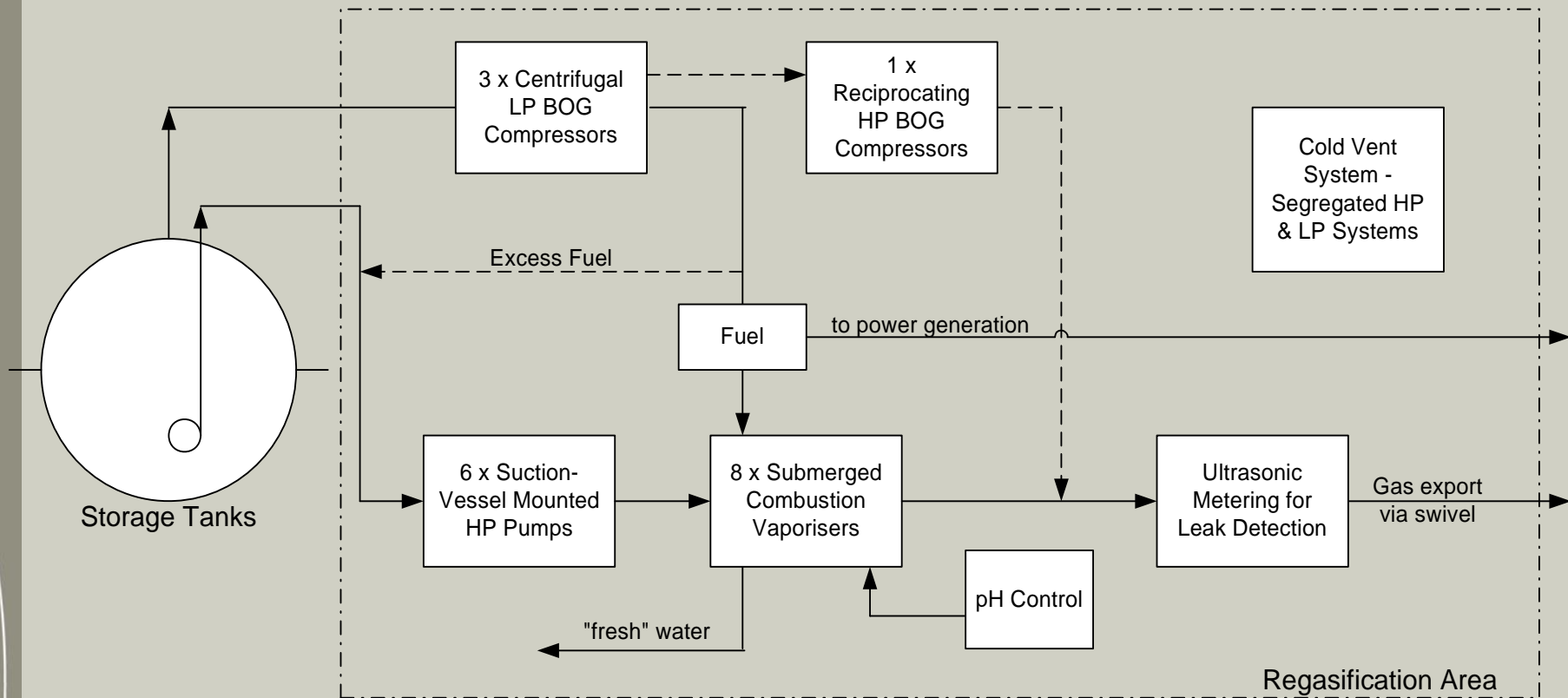
# Cabrillo Port

## Floating Storage & Re-gasification Unit (FSRU)

- L~290m B=65m D=31m Draft=13.2m
- Displacement ~ 210,000 DWT
- 3 x 56m Diameter Spherical LNG Tanks
- LNG Storage = 275,700m<sup>3</sup>
- POB = 50 men
- Installed Generation ~ 30MW in 4 units.
- Normal Throughput = 650 - 900 MMSCFD
- Re-gas submerged combustion vaporizers
- Permanent Bow Turret Mooring in 870m wd.
- Two 3MW Thrusters for heading control



# Regasification Process Block Diagram

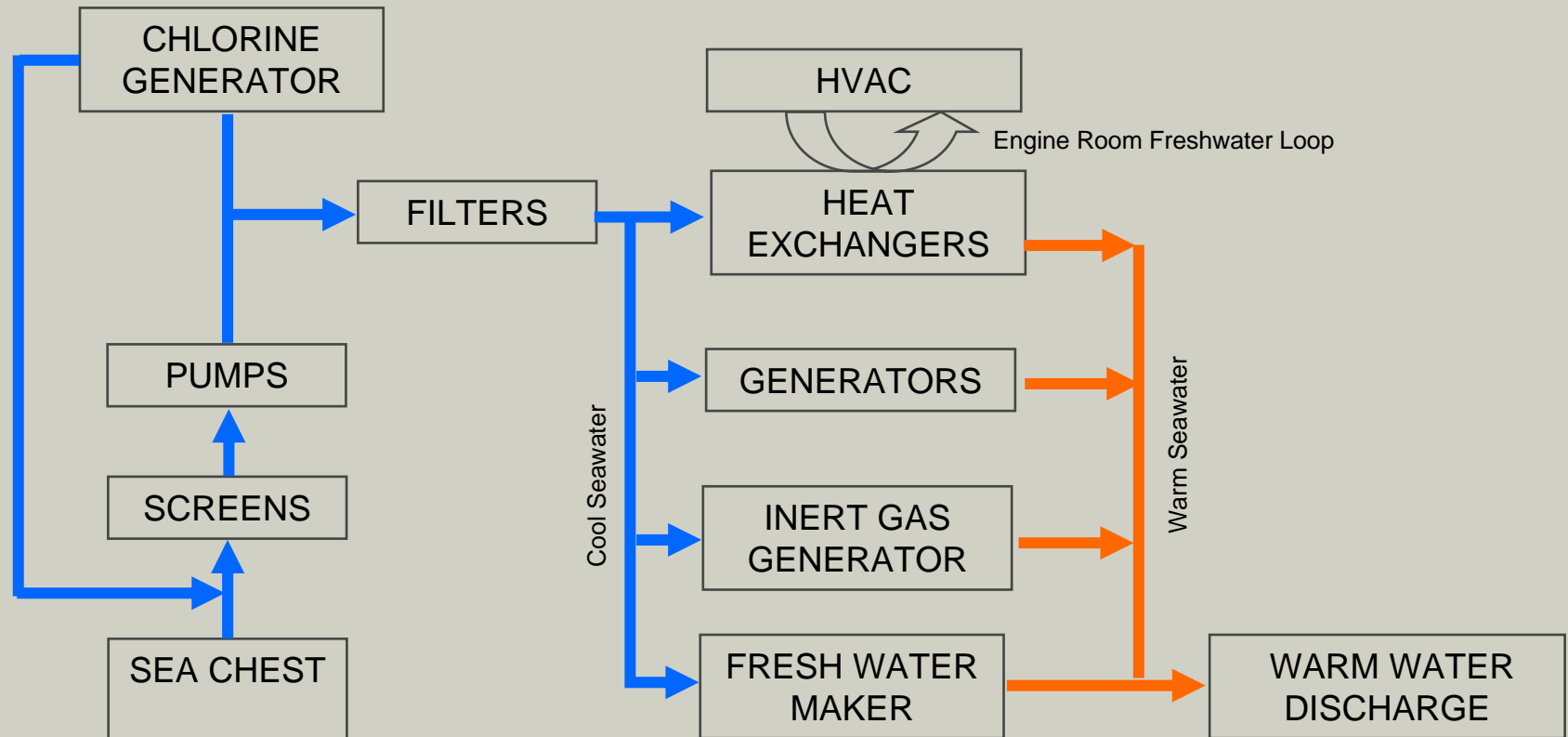


### Previous Design Basis - Standard Marine Cooling System

- Standard marine technology uses sea water for cooling
  - Tankers, bulk carriers and general shipping
  - LNG carriers
  - FPSO's
- Sea water is used to cool / remove heat from marine equipment such as:
  - Power generators
  - Inert gas generator (intermittent user)
  - Air conditioning in accommodation modules
  - Compressors
  - Fresh water makers
- Sea water is screened/filtered to remove seaweed etc. and treated chemically to prevent marine growth in the equipment



## Sea Water Cooling Schematic (Typical Marine Application)



# Redesign of Cabrillo Port FSRU Cooling System

### DRIVERS

- CCC concern about seawater discharge in excess of CA thermal plan
  - Initial design exceeded thermal plan by 9 deg F
- Trade off between thermal plan exceedence & bio-mass
  - Utilize more cooling water → results in lower seawater discharge temperature but **increases** bio-mass intake

### CHALLENGE:

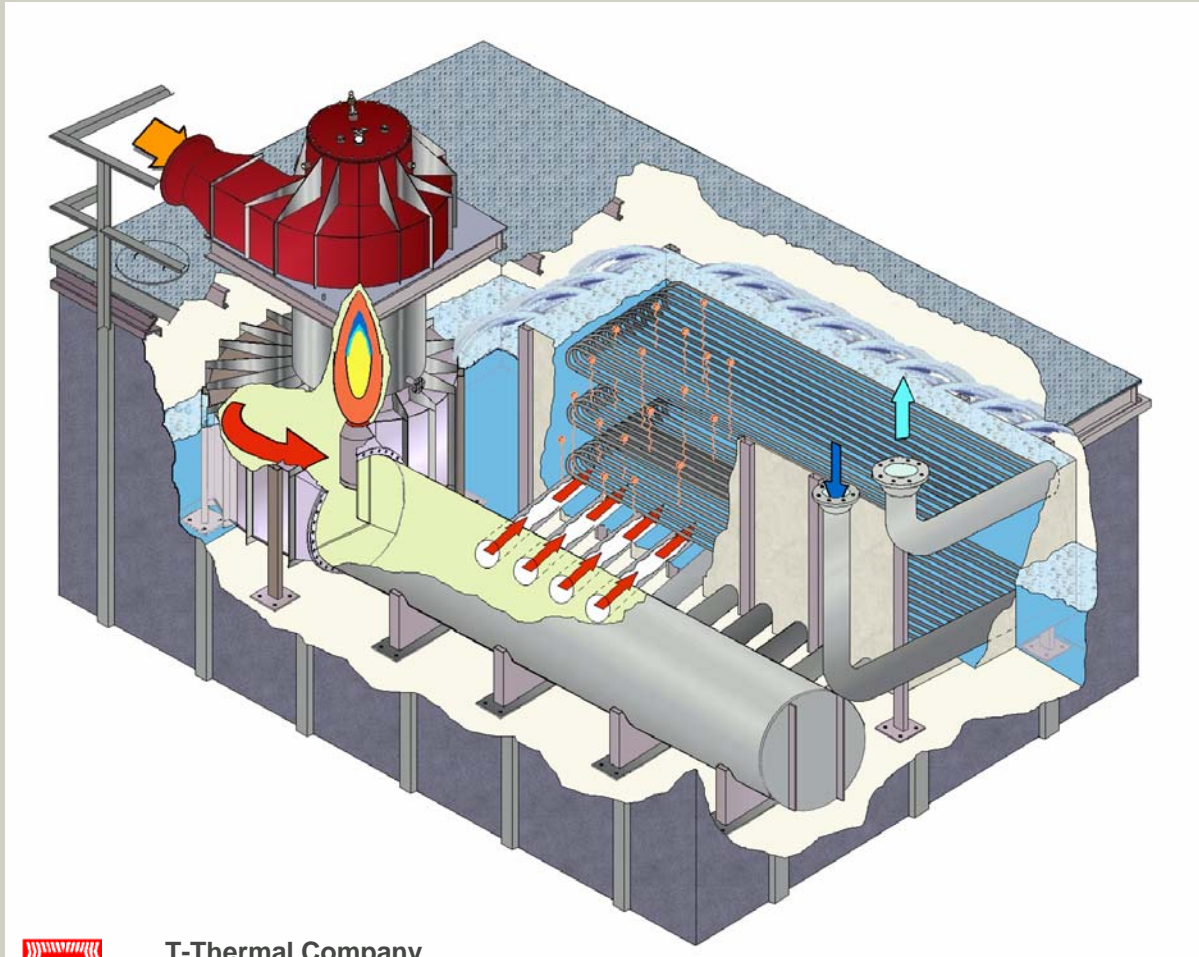
Find a solution to CA thermal plan without impacting bio-mass under normal operation

### SOLUTION:

Utilize the available cold LNG to provide cooling for the heat generating sources on the FSRU

## Sub-X<sup>®</sup> “Single Burner” Vaporizer

- Compact, high thermal efficiency (99%),
- Low NO<sub>x</sub> (20ppmv) emissions,
- 50m<sup>3</sup>/hr fresh water discharge
- Ample room to accommodate additional heat exchanger coils in outer shell.



The diagram illustrates the ship's cooling system, divided into two main sections: the Forward Deck and the Engine Room, separated by a dashed line.

**Forward Deck:**

- Two **SCV** (Seawater Circulating Valve) units are shown, each with a pump and a valve.
- Cool SCV Water** flows from the SCV units through a pump and a valve into the **Engine Room**.
- Warm SCV Water** flows from the SCV units through a pump and a valve into the **Engine Room**.
- Cool Tempered Water** flows from the SCV units through a pump and a valve into the **Engine Room**.
- Warm Tempered Water** flows from the SCV units through a pump and a valve into the **Engine Room**.
- An **Expansion Tank** is connected to the **Cool Tempered Water** line.

**Engine Room:**

- A **Backup Seawater Cooler** is connected to the **Cool SCV Water** line.
- The **Backup Seawater Cooler** feeds into the **HVAC (~11%)** and **Generators (~89%)** systems.
- Warm Sea Water** flows from the **Backup Seawater Cooler** into the **HVAC** and **Generators**.
- Cool Sea Water** flows from the **Backup Seawater Cooler** into the **Inert Gas Generator (IGG) (intermittent service)**.
- The **IGG** is connected to the **Sea Chest (normally isolated)**.
- The **Sea Chest** is connected to the **Sea Water overboard**.



### Design Solution -Tempered Water Loop with Seawater Backup

- Advantages:
  - Tempered water loop maintains segregation between Engine Room and Process Area (barrier fluid)
  - Tempered water is a non-corrosive fluid
  - Utilize sea water pumps required for IGG as back-up
  - Low additional deck space required (pumps + plate exchangers)
  - Utilizes readily available standard components (pumps, exchangers)
- Disadvantages:
  - Additional tempered water circulation pumps
  - Additional expansion tank

### Sea Water Usage with Tempered Water Closed Loop System

- Sea water used intermittently – SCV's out of service (4 days / yr)
  - Maintenance and scheduled downtime (e.g. tank inspections)
  - Unscheduled downtime:
    - Weather
    - Equipment breakdown
  - No gas export
- Inert Gas Generator
  - Non-seawater options investigated but none have been found to suit the needs for marine operation
    - Require high volumes and high flow rates
  - Annual usage is 4 days per year for entry and inspection of LNG tanks

# Closed Loop Cooling System - Technical Viability

- Additional Equipment

- Tempered water and SCV water circulation pumps (4 total)
- Seawater backup heat exchanger (1 only)
- Tempered water / SCV water heat exchangers (2 total)
- Tempered water expansion vessel (1 only)

(Note – all of the above are readily available off the shelf components, and require no technology advancement)

- Design has been reviewed and verified as operable by marine operations personnel
- Bottom line – Design is well advanced and far beyond the “smoke and mirrors” stage as recently referenced in the press

## Seawater Cooling Elimination - Summary

Seawater cooling eliminated during normal operation (all but 4-8 days/yr)

- Environmental Benefits
  - No seawater discharged → conforms with CA Thermal Plan
  - No marine growth inhibition required
  - No intake of sea water → no biomass removed from environment
- Additional Benefits
  - Reduced fuel gas consumption through heat integration
  - Reduction in air emissions
- Disadvantages
  - Increased CAPEX – approximately \$3 MM, + / - 25%
  - Some additional complexity for operations